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ABSTRACT

The principle of education for all is one which few people, if any, would argue against but putting it into practice is one of the biggest challenges facing everyone involved in education. Internationally, nationally and locally attempts are being made to develop and put in place policies and structures which will lead to an inclusivity of education which meets the needs of all students. Children with learning difficulties are only one group for whom access to many aspects of education have been denied. Despite the obstacles, however, there has been much progress in opening up opportunities for them. However, unless teachers are able to help these children access the curriculum, the policies and structures that have been put in place are of little value. This paper examines some of the challenges facing teachers of children with learning difficulties in primary schools as they try to make science accessible to their pupils. Traditionally, such children have been given little in the way of scientific problems to explore but, it is argued, that science can make a significant contribution to the education of children with learning difficulties. The value and effectiveness of the contribution will be realized only if teachers can recognize the barriers to learning that these children face and have the skills to help their pupils overcome these difficulties. Examples of teacher-pupil interactions are used to illustrate the issues raised and some implications for mainstream teaching suggested. (Author)

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Accessing science in the primary school: meeting the challenges of children with learning difficulties.

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Abstract

The principle of education for all is one which few people, if any, would argue against but putting it into practice is one of the biggest challenges facing everyone involved in education. Internationally, nationally and locally attempts are being made to develop and put in place policies and structures which will lead to an inclusivity of education which meets the needs of all students. Children with learning difficulties are only one group for whom access to many aspects of education have been denied. Despite the obstacles, however, there has been much progress in opening up opportunities for them. However, unless teachers are able to help these children access the curriculum, the policies and structures that have been put in place are of little value.

This paper examines some of the challenges facing teachers of children with learning difficulties in primary schools as they try to make science accessible to their pupils. Traditionally such children have been given little in the way of scientific problems to explore but, it is argued, that science can make a significant contribution to the education of children with learning difficulties. The value and effectiveness of the contribution will be realised only if teachers can recognise the barriers to learning that these children face and have the skills to help their pupils overcome these difficulties. Examples of teacher-pupil interactions are used to illustrate the issues raised and some implications for mainstream teaching suggested.

Key words: *learning difficulties; primary science; special needs; inclusion.*

Introduction

It is widely acknowledged that science can, and does, make a significant contribution to the learning experiences of children with learning difficulties (see for example , not only in terms of the development of science knowledge, concepts and skills but also through the opportunities for children to increase their self-esteem and develop many of the elements of self-advocacy . Despite such recognition of the value of science to the education of children with learning difficulties, research in the area is not extensive. Few studies have looked specifically at teaching and learning in science of primary age children with learning difficulties. This paper reports some outcomes of a research project, funded by the Nuffield Foundation and undertaken in the UK, to explore some aspects of teaching and learning in science for primary school children with learning difficulties.

The project was set up as a result of a conversation with two teachers from a special school who felt that they could be doing more to help the children in their school benefit from the science work they were doing. More specifically the teachers felt that the children understood more than they were able to show. Furthermore, if, as teachers, they were able to help the children express their ideas more completely and clearly then it would be possible to build on this and increase the access these children have to the science curriculum itself as well as maximising the other perceived benefits of having science in the curriculum for such children. This paper therefore sets out to:

- provide an overview of the contribution science can make to the education of children with learning difficulties;
- identify some of the challenges faced by teachers and children in maximising the benefits of science in the curriculum;
- report the findings, and consider some of the implications, that have arisen from an examination of conversations between children and their teachers in relation to a number of science topics studied during the current project.

Science and children with learning difficulties

The 1988 Education Act and the National Curriculum Statutory Orders, which followed in the UK, have clearly stated that children with Special Educational Needs should follow the National Curriculum to the maximum extent possible. The publication of the Code of Practice on SEN provision further emphasised the responsibility of teachers to provide appropriate learning opportunities for children with SEN. Although the Code of Practice refers to eight types of special educational need - learning difficulties, specific learning difficulties, emotional and behavioural difficulties, physical disabilities, hearing difficulties, visual difficulties, speech and language difficulties and medical conditions - the reality is not as clear cut. Thus, although the work of the project mainly involves children who are statemented as having moderate learning difficulties, some of the children have other special educational needs which have to be catered for.

In many respects it is difficult to define precisely what constitutes moderate learning difficulties because of the range and complexity of problems faced by each individual child. The difficulties they encounter may also vary according to the curriculum area being investigated, however, such pupils, to a lesser or greater extent, will have difficulty in, among other things:

- gaining access to the curriculum through normal teaching and learning approaches
- acquiring concepts and achieving the standards expected in terms of National Curriculum level descriptors
- processing language and instructions
- expressing their own ideas
- retaining and applying previous learning.

In addition the behaviour of such children may be attention seeking, inattentive and disruptive with shows of frustration and a general lack of motivation. These outward expressions of behaviour may result directly from the difficulties an individual child has or from a mismatch between the learning provision available and the needs of the child in question.

One of the key issues for debate in relation to teaching and learning for children with special needs in general and learning difficulties in particularly as been clearly articulated by in his consideration of the Code of Practice . He argues that assessment of children's performance and their failure to learn is automatically the result of a learning difficulty and goes on to suggest that,

> *The critical issue which needs to be addressed is whether starting from the assumption that children will learn with appropriate teaching, will lead to different educational outcomes for children than when starting from the assumption that low attainments reflect a difficulty in learning.*

picks up this theme when he argues from work of that schools which are,

> *orientated to promoting pupil effort, with continuous emphasis on strategic learning behaviour, and embody a belief in each child's ability, are more likely to be associated with success.* {and} *..that teachers in such schools are more prone to believe that they can successfully teach each child and also view themselves as learners. They, thus, treat teaching as a competency to be continuously developed, and a child's failure to learn as a problem to be solved by teaching.*

It is against this wider background that the present study was undertaken and the findings considered.

Whilst there is a wealth of material available relating to special educational needs generally and children with learning difficulties more specifically there is little available which examines teaching and learning of children with learning difficulties in particular subject domains; science is no exception. Yet there is some evidence which suggests that children's perceptions of their academic abilities are specific to different content areas and that it is not unreasonable to suggest that they may be more able to succeed academically in some content areas than in others.

In a series of articles over the last ten years Mastropieri and Scruggs (see for example have drawn together much of the literature and evidence base that supports the generally accepted view that students with learning difficulties and other special needs can benefit significantly from the inclusion of science in their education. Much of this work has been carried out in the USA and supports the stance that 'science can develop background knowledge, promote concrete learning experiences and develop problem-solving and reasoning skills.' . Maximising the potential of science work for pupils with learning difficulties, however, is not entirely straight forward. On the contrary it is a major challenge for even the most accomplished teacher.

Studies which have considered teaching and learning in science for children with learning difficulties have focussed on three main issues - the appropriateness of 'hands-on' science (e.g. ; the implications of constructivist approaches to learning ; and forms of assessment - which reflect the main trends that have developed in mainstream science education over recent years and remain part of a continuing debate . Although each of the three issues will be briefly considered in turn below, it should be emphasised that they are not separate matters, rather they are very much overlapping and intertwined.

Appropriateness of 'hands-on' science

The term 'hands-on science' is used as a shorthand expression to characterise an approach to teaching and learning in science that has developed, particularly in the primary school, in which children are able to gain first hand experience of objects, situations and scientific phenomena. Other terms such as 'inquiry-based' and 'investigative' science perhaps better emphasise the fact that such an approach has a purpose in developing understanding of science concepts as well as developing expertise in the processes and skills of science. As suggested by Champagne *et al* in their analysis of trends in science education ,

> ...changes focus on getting students to participate actively in doing science and on creating learning environments that reflect science as it is practised. Specific trends are to (1) engage students in investigations of the natural world that reflect the ways in which scientists inquire; (2) provide students with opportunities to work in small groups; (3) involve students in tasks that reflect the ways in which people use scientific information and inquiry processes to make personal and social decisions; and (4) help students to know that science is for everyone.

Clearly such an approach would appear to be very appropriate for children with learning difficulties. in their analysis start from this premise and argue that hands-on approaches are more likely to succeed for children with learning disabilities because of the reduced emphasis on the use of texts and abstract textual learning in favour of more concrete experiences and physical interaction with the scientific phenomena. Indeed in their study in which they compared the relative effects of textbook-based and inquiry-based approaches to science learning in special education classrooms, Scruggs and Mastropieri found that,

> ... hands-on science activities were greatly favoured over textbook activities by students who had experienced both. {and hands-on activities were considered by the students to be}.. more facilitative of learning, more motivating, and more enjoyable than the more traditional textbook activities. {furthermore in the context of the study}... when students were taught by experimental, more indirect methods, they learned more, remembered more, and enjoyed learning more than when they were taught by more direct instructional methods.

Despite such positive findings, the use of inquiry-based approaches is not a panacea for teaching children with learning difficulties. Teachers need to adapt their approach and organisation to meet the wide variety of children's needs they encounter. This was followed up in a subsequent studies in which, first, characteristics shown by children with learning difficulties impact on the success or otherwise of inquiry-based approaches, and , second, the effectiveness of such approaches on the learning that actually takes place. In the first of these studies considered the four characteristics - (a) attention, (b) semantic memory, (c) logical reasoning, and (d) outerdirectedness - which 'appear to be particularly relevant to science education.'

(a) Attention

The ability of a child to focus on a task over a sustained period of time is often something which children with learning difficulties find difficult but more specifically such children do not readily recognise features that are relevant to the task in hand. They frequently focus on things which are irrelevant thereby hindering the learning process. Such pupils do concentrate on the appropriate points may appear to progress in a similar manner to that of pupils with normal ability. Although lack of attention and the ability to recognise relevant details can present barriers to learning during investigations evidence provided by indicates that these can be successfully addressed by teachers. This supports the findings of our own work reported in this article and elsewhere

(b) Semantic memory

Although engagement in hands-on activities reduces the demands on children's verbal memory and their ability to recall particular words and phrases, scientific investigations do require children to communicate ideas and for them to understand the meanings of words. Science has its own technical vocabulary and it also shares words with everyday language, both of which place demands on children's learning in science. Scruggs and Mastropieri found that teachers needed to rehearse words frequently, encourage children to link the words to familiar experiences through multiple presentations of the terms as well as reducing the demands of vocabulary for the children. In these situations the use of more direct instructional approaches, such as mnemonic instruction, appear to be necessary .

(c) Logical reasoning

Scientific enquiry requires engagement with the processes of science such as predicting, inferring and problem solving all of which place demands on children's ability to reason in a logical manner. For children with learning difficulties such reasoning does not come easily and as such can be an inhibitor to their learning through enquiry based approaches. This is not to say that they cannot achieve some success in developing their reasoning abilities. Indeed, as reported,

> recent investigations have suggested that students with LD {learning difficulties} who are coached to actively reason through certain types of academic content both remember and understand that information better than control condition students.

(d) Outerdirectedness

use the term outerdirectedness to refer to the way in which children with learning difficulties attempt to use and rely on external cues they pick up from their surroundings in order to respond to questions. This may involve repeating things said or done by other children, responding to teacher actions, and taking information from pictures and other objects in the room regardless of their relevance. The ability to use external cues can be very productive and in many situations is to be encouraged. Children with learning difficulties, however, appear to become over reliant on the opinions and behaviours of others and very reluctant to use their own judgement and reasoning . A tendency towards outerdirectedness, at least in part, would appear to suggest a lack of self confidence in such children. Although not always straight forward the study indicated that the use of a hands-on approach to science provided teachers with the opportunities to build in positive experiences for children. These along with the emphasis on the scientific process skills - observing, comparing, predicting and inferring - increased the likelihood of children having more confidence in their own ability.

Implications of constructivist approaches to learning

Science education over the last ten years has been strongly influenced by what can be described as constructivist approaches to teaching and learning in which learners are considered to be actively involved in the construction of meaning of concepts for themselves. Detailed discussions of the range of constructivist views can be found elsewhere in the literature . Essentially interpretation of constructivist views range from that of personal constructivism in which individuals construct their own knowledge and understanding of the world, to that of social constructivism in which tends to view the learning process as one of enculturation in which the learner becomes part of the learning community. Social constructivism does not dismiss the idea that individuals come to make sense of their own learning rather it builds on this view adding further dimensions to the learning process. Broadly these are: the role of interaction with others during the learning process through discourse and dialogue; the existence of shared knowledge and the incorporation of this into both personal and community understanding of the concepts in question; and the need to access the knowledge systems of science itself.

More recently there has been increased emphasis on the role of the teacher in helping children construct meanings based on

their existing ideas and experiences with a view to developing their understanding of the world around them. The renewed interest in the work of Vygotsky has added support to both thinking and research into approaches to teaching. In particular the concept of scaffolding, a term which according to was first used by , provides a powerful tool for teachers to use in creating opportunities for children to engage with new ideas. It also provides support for children to cope with tasks which are too complex for them to manage on their own. Although not specifically in science , claim that scaffolding

- is multilevel, aimed at curriculum, the classroom, and the individual learner.
- is inclusive, helping individual students to learn in appropriate ways.
- is aimed at promoting higher-level thinking.
- is dynamic and evolving.
- {and} can move the entire class forward, ensuring that individual students with disabilities fully participate, contribute, and learn.

(p 165)

Although they are more cautious in their claims for teaching based on constructivist approaches linked to coaching argue that in science,

> students with disabilities have been seen to benefit from appropriately sequenced activities that require inductive and deductive thinking. {and}... that interventions that require students with disabilities to actively reason through academic content often do facilitate memory and comprehension objectives.

Forms of assessment

Assessment has long been an area of concern in all phases and areas of education. The literature is full of debates around the purposes and practices of assessment. Science education is no exception. Three broad areas of science need to be assessed - conceptual understanding; science processes, reasoning and practical skills; and the application of concepts to new situations - each of which present particular challenges in terms of the means of assessment. There is a vast amount of literature which debates these issues and it can be argued that all forms of assessment can be of value providing the limitations are recognised and interpretation is undertaken with caution. Formative assessment, however, is pivotal to any approach to teaching and learning that gives value to children's ideas, since finding out their ideas initially and then frequently checking to find out how they have changed is a pre-requisite to teaching for understanding. Black and Wiliam's recent review of literature on formative assessment concludes that,

> There is a body of firm evidence that formative assessment is an essential feature of classroom work and that development of it can raise standards. We know of no other way of raising standards for which such a strong prima facie case can be made on the basis of evidence of such large learning gains.

There is evidence that for children with learning difficulties the form and format of the assessment being used will significantly influence the outcome. , for example showed that children were able to access and use their knowledge better using a constructed diagram format than when they were faced with an open-ended questionnaire. In a subsequent study they present additional evidence that the format of assessment influences children's performance and the need for multiple assessment tools to provide a more comprehensive picture of the children's understanding and abilities. Particularly for children with learning difficulties assessment should not be simply about determining their achievements in terms of the subject matter (both content and skills) it should also look to support their learning in other aspects of their development. present evidence to show how the use of 'student journals' as part of the assessment process offered the opportunity to note children's progress in terms of their improved 'mastery of the *discourse of science* ' (p59) and 'the development of a sense of *personal agency* or *efficacy* ' (p59).

Although there is a substantial body of research (see for example available which has explored ways of accessing children's ideas in science, many of the techniques do not appear to be completely applicable to children with learning difficulties. Most of the techniques require some degree of modification and often a change in the way elicitation of ideas is conceived and practised. It is, however, essential that attempts are made to investigate modified or new approaches if the abilities of children with learning difficulties are to be fully recognised. Perhaps, more importantly, it is necessary to find ways in which such assessments can be used formatively in order to further children's learning.

This brief discussion of trends in science education in relation to children with learning difficulties provides good evidence that science does have a significant contribution to make to the curriculum for such children. It also indicates that there are significant challenges that have to be faced if the potential of children with learning difficulties is to be realised. It was with this background in mind that the present project was developed and the outcome interpreted. There was a substantial amount of anecdotal evidence from teachers of children with learning difficulties to suggest that there was a need to explore a range of teaching strategies that could help children express their ideas about science concepts more clearly. Thus the ASSEN (Accessing Science for Special Educational Needs) Project was set up.

The ASSEN project

The project was carried out in partnership with practising teachers from four special primary schools in England and researchers from Liverpool Hope University College. The data were collected over two year period through one to one activities with individual

children, classroom based observations, field notes taken by the researchers, as well as written and verbal comments on the activities from the teachers. All the children involved were between the ages of 7 and 11. Following several preliminary visits to the schools during which science lessons were observed followed by informal discussions with the teachers, a programme of tasks to be carried out was agreed. Each of the tasks followed the same pattern which involved teachers in each of the 8 classes (two per school) undertaking a short activity with the whole class, and a sample of children from each class were asked to undertake a more detailed version of the task individually. Children's work from the class tasks was collected by the teacher who, where necessary annotated the work to indicate particular difficulties that were experienced either by the children or by them, as the teacher, in carrying out the task in the classroom. Detailed records were made of the tasks undertaken with individual children providing examples of the children's work plus a transcript of the discussion that had taken place. The transcripts were further annotated as soon as possible after the event in order to provide further information relating to the responses made by the child. Approximately once every three months a meeting was held with the teachers involved to discuss and reflect on some of the issues that had arisen from the work and preliminary analysis that had been completed to date.

In all over the period of the project 7 science topics were used: electricity, sound, dissolving, forces, floating and sinking, habitats, and light. The selection of topic and the detail to which it was explored during the research project were subject to the constraints of individual school situations. The initial data analysis was attempted to identify: the major themes that were evident in the children's responses to the tasks; the factors which appeared to either encourage or hinder the children to reveal their ideas about the topic being discussed; and the issues which the teachers perceived as contributing to the success or otherwise of the task. This paper provides a summary of some of the main messages which have emerged and will examine in more depth some of the findings that are derived from a more detailed analysis of the transcripts of the one-to-one dialogue with individual children during four of the tasks. The tasks in question related to work on electricity (constructing a circuit), dissolving (putting table salt and sand into water) and two relating to habitats (matching animals and plants to the places in which they live). Other relevant material from the other topics has been used to further aid interpretation of the findings were appropriate.

Some messages

The key theme that has constantly recurred throughout the project has been the need to identify ways in which a dialogue (both through discussion and / or action) about a science topic between teacher and pupil might be maintained. The importance of this need is underlined by teachers who frequently commented that they felt children with learning difficulties often know more than they reveal. Therefore the data was constantly being examined for evidence of ways in which such dialogue was being enhanced and for ways in which it was being inhibited. In other words, what were the 'triggers' and what were the 'barriers' to children expressing their ideas and ultimately to their learning. Thus finding ways of keeping the conversations going was a major aim of the project. To date the emerging messages, which seem obvious when written down, appeared not to have been fully recognised by the teachers in the day-to-day hurley- burly of the classroom.

1. *Children's ideas*

   Although it may be stating the obvious, it is worth emphasising that children with moderate to severe learning difficulties do have ideas about scientific phenomena. What is more, even in the early stages of the project, some of the children, when given the opportunity, demonstrated levels of understanding that were not expected by their teachers. It is also clear that many of the ideas expressed by these children are similar to those identified by other research with children in the normal ability range .

2. *Language*

   Not surprisingly, language and its use are a major difficulty for many of the children and a great deal of research has been carried out into the problems they face. In the context of this project we have noted, particularly, the careful thought which must be given to the questions asked and the words used. These issues are considered in more detail below.

3. *Materials and equipment*

   The selection of materials and equipment must be given a great deal of thought as inappropriate choices create barriers for the children. For example 'the bulbholder effect', arose during an interview in which one of the children was trying to put together a simple circuit. She was experiencing some difficulty in manipulating the wires and bulb, when the interviewer asked,

   Interviewer *Would you like me to hold something for you? Would it be easier?*

   Child *A battery hold (pause)....a holder (pause).... a bulbholder*

   Interviewer *Do we need a bulbholder?*

   Child *Yes*

   The child was then given a bulbholder and completed the circuit very efficiently. A similar incident happened with another child which raised a question as to the importance of the bulbholder in this situation. Further explorations with children who had not been able to complete the circuit without the bulbholder showed that most of them were able to do it once a

bulbholder was provided. The importance of the bulbholder was emphasised in the children's drawings of circuits to which the children added a bulbholder whenever it was not included. This reflected the experience the children had had in making circuits earlier in the year and the importance they had attached to the need for a bulbholder in order to construct a circuit.

On another occasion children were investigating the process of dissolving by putting table salt into water. When asked what the colour of the resulting solution was, they replied 'blue'. Nothing the teacher did would persuade them otherwise, thus leaving the children with the strong impression that when table salt dissolves, the water turns blue. When the teacher reflected on the activity and looked for possible explanations for this response she realised that the clear plastic containers she had been using were in fact tinted blue. Hence the children were 'correct' because when they looked at the solution through the side of the container it was 'blue'.

4. *Use of worksheets*

The use of worksheets can be helpful for getting children to record their ideas by reducing the pressure to write long responses but, unless carefully thought out, the same worksheets can inhibit children expressing their ideas. For example, one teacher used symbols to supplement the words 'float' and 'sink'. The symbol (i.e. for 'sink' the object was suspended in the middle of the container), however, did not show exactly what the children saw (i.e. when an object sank it went to the bottom). Many of the children were obviously confused and were unable to match their observations to the symbols on the worksheet. Yet subsequent conversations with the children revealed that they could clearly recognise when things float and sink.

The use of worksheets and other visual material were helpful in many respects but repeatedly children were distracted from the main point by other objects or patterns in the picture. By reducing the unnecessary elements of pictures and worksheets it was found that children were more likely to focus on the issue in question.

5. *Development of process skills*

The work of the ASSEN project indicates the importance of helping children develop their ability to carry out the process skills. In many situations children's weaknesses in these skills proved to be restricting their ability to show what they understand of particular concepts. For example the majority of the children had particular difficulty in making predictions without a familiar context thus emphasising the importance of the concrete experiences needed by these children. The need to make explicit the steps involved in carrying out the process skills is also important in helping these children engage with the activities. As with the development of concepts the process skills need to be built up in small steps in order to help the children improve their ability to use the skill in question. For example the process of sorting involves, among other things: recognising the features of objects; recognising that some features are the same and some are different; grouping of objects requires objects with common features being put together and objects with different features belong in another group. Helping children become proficient in the different elements of each of the process skills is an important step in improving their access to science and, it might be argued, their self confidence.

Exploring the dialogue

One of the biggest challenges to teachers working with children with learning difficulties is what to do when a question they have asked gets no response or the child simply says 'I do n't know'. Such a response, or lack of response, can mean quite simply 'I don't know' or it might mean 'Don't hassle me I need time to think', or it might mean 'I don't think I know because I don't recognise anything about it'. There are probably other interpretations as well but it would seem that the challenge to the teacher is to find a way of reopening the conversation or to recognise that they need to stop and give the child some 'breathing space'. With this in mind, therefore, the transcripts were examined and each point at which the child failed to respond or said 'Don't know' was noted. Each question which lead to such a lack of response was noted and categorised. The exchange that followed was then examined and also categorised as to the effect it had on the child's subsequent response. The purpose of this form of analysis was to identify first, the type of questions which were likely to result in a 'Don't know', and second, to ascertain the nature of the strategy used by the teacher which enable them to take the conversation further and help the child express more of their ideas about the topic. Tables 1 and 2 provide a summary of the findings.

Table 1

To show the different events which lead to a 'don't know' response

Event (Total number of interactions = 812)	Number of 'Don't knows' (Total = 108)
1. Types of question	
Factual recall	39
Explanation of observation	9
General open question	8
Procedural	6
Recall of previous experience	3
Reference to previous action	3
Focus on observation	2
Change of procedure	1
2 Other events	
Difficulty with task	27
Distractions	10

The teachers in the project were all experienced in working with children with learning difficulties therefore it was not surprising that they were able to keep discussions going with children. For the purposes of this analysis a total of 51 one-to-one conversations with 15 children were examined. The conversations varied in length but in total 812 interactions were recorded of which 108, approximately 14%, involved a 'don't know response. There is still much more detailed analysis to be done but from the analysis so far, as can be seen in table 1 questions which ask for factual recall are very likely to bring the dialogue to a halt. Asking for explanations and open question would also appear to cause some difficulty whilst questions that ask children to link their observations with their previous experiences or something they have just done are less likely to be inhibiting. Difficulties with the actual task and distractions were also significant events which resulted in a 'don't know' response.

Table 2

To show type of intervention made by teachers and the outcomes resulting from the interventions.

Type of intervention	Progress	No progress	Total
Gives a clue	17	2	19
Sequence of direct questions	13	2	15
Clarification of the question	6	6	12
Change of focus	10	2	12
Encourages the child to have a go	10	1	11
Gives word / answer	6	2	8
Word / sentence completion	7	0	7
Focus on specific aspect of the task	1	6	7
Doesn't proceed	0	4	4
Suggests next step	2	1	3
Builds up steps in solving the problem	3	0	3
Refers to previous action	1	1	2
Gets child to use imagination	1	1	2
Reinforces positive acts to date	1	0	1
Helps work through task	1	0	1
Get child to draw a response	1	0	1

These initial findings in general support what is usually considered to be good advice given to teachers in training. One particular area which needs further consider, however, is that of the use of open questions. Although the occurrences of such questions are not the most frequent they are probably significant and follow up discussions with the teachers suggest that the use of open questions, contrary to advice from elsewhere, are not helpful to these children. A more direct and structured approach would appear to be to be more effective, as suggested in table 2 which shows the types of intervention used by the teachers in response to 'don't know' answers. The most frequently used technique of 'giving a clue' was very successful as was the use of a series of direct questions. Indeed the majority of interventions used resulted in some progress being made which reflected the skills of the teachers in being able to respond in an appropriate manner.

Although the analysis is still in its early stages it is clear that there is no single strategy that is used by teachers in all situations. It is the use of a wide range of interventions which helps to keep the conversations going and bring out new aspects of the children's understanding. Particularly important is the need for teachers to provide some kind of 'mini-scaffold' which will help the child go a little further with their explanation. For example, this child was having difficulty responding to questions about how an electrical circuit he had made worked, but the intervention of the teacher with a simple piece of 'scaffolding' brought a positive response.

Teacher *So the wires and the clips make it light up?*

Child *Yes*

Teacher *How did the wires and the clips make it light up?*

Child *No response*

Teacher *The bulb lit up because ....*

Child *because the wires connected it to the screws and to the battery.*

Discussion

Working with children with learning difficulties is not easy but from the evidence obtained during this project there a many teachers who are successful and there are many more who could be more effective if some of the strategies used by the good teachers could be made more explicit. To date it would appear that there are some simple things that can be done to improve the responses from these children. The solution, however, is not as straight forward as that. It is not simply knowing the techniques that will solve the problems, it is related to the skills and knowledge of the teacher as well as their general view of learning in general and that in relation to children with learning difficulties in particular. For example, the majority of primary teachers lack confidence and knowledge in science. For those teachers working with children with learning difficulties, however, the ability to understand and recognise the small incremental steps that might be linked to help children develop even the early understanding of a scientific concept is an asset that they, the teachers, do not necessarily possess. Similarly, the teaching and learning strategies often have to be more specific in order to meet the learning needs of the children. As one of the teachers in the project school said,

> *I'm doing my best, but I wish I could do more for the children. To do that we need more information and other, more suitable, materials.*

More generally it is worth returning to the ideas expressed by so that helping children to learn starts from the assumption that all children can learn with appropriate teaching and support. This argument can be further developed if it is assumed that all children have special educational needs in the sense that each child is an individual and therefore should be treated as such. On this basis the principles discussed for SEN and mainstream children would be the same and the aim would be to help them not only come to an understanding of concepts within the different subject areas but also to learn things which are of value to them as members of society. The challenge for schools and teachers is being able to identify what each child needs and to respond accordingly.

Such an argument then raises the question of how this can be done in practice? To raise the question is easy but to answer it is much more elusive. More detailed studies such as that reported in this paper will contribute to a clearer understanding of some of the pedagogical issues and to address questions such as:

- what type of learning does the child respond to?
- what barriers need to be overcome?
- how small do the steps forward need to be for progress to occur?
- how can such progress be recognised and communicated to the child (formative assessment and constructive feedback)?
- how can the child be let in on the secret without simply telling them the answer?

Ultimately, for all children education should be a positive experience through which they are able to feel they have succeeded and the value of each area of study be recognised. The contribution that learning in science makes can be significant for all children not least because it provides opportunities for them to develop an understanding of the world around them, a sense of empowerment through choice, and a feeling of self-worth.

Bibliography

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